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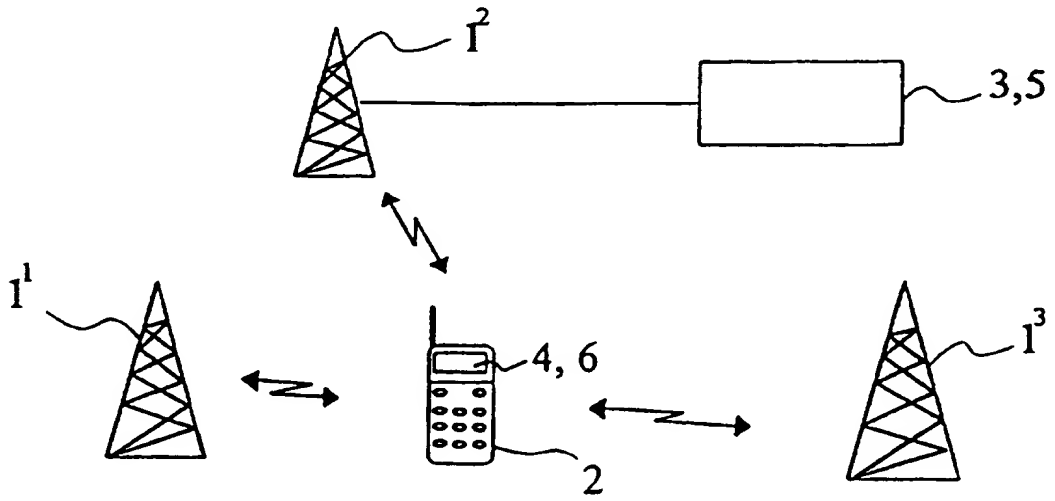

(57) Abstract

The invention is utilized for calculation of continuous location information of a digital cellular phone or any other location device based on the cellular phone in the transmitter itself in the same way, as the GPS-location system (Global Positioning System) terminal device is used. According to the invention it is received from the cellular phone system a location information for the base station, which information is obtainable also in inner spaces and in corresponding closed spaces, and the location is determined by the location device integrated to the mobile station. The location device integrated to the mobile station and utilizing the mobile station network does not influence significantly the readiness times of the present cellular phones.

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Location method and system

The present invention relates to a location method defined in the introductory part of claim 1 and a location system defined in the introductory part of claim 10.

Numerous location methods and location devices are known before. One commonly used system is the GPS-system (GPS, Global Positioning System). The GPS-system comprises a world-wide navigation and location system based on the determination of time and distance and including 24 satellites orbiting the globe. The satellites orbit the earth at the height of 20200 km at six track levels and their orbit time is about 11 hours. Each GPS-satellite sends radio signals at the frequency of 1575,42 and 1227,6 MHz. To both carrier waves are added the modulated updated information concerning the satellite's track and the necessary time signs. Coordinate data of the satellites will not be sent. The location is carried out by a location device compatible with the system so, that the information sent by the satellites is received and the location of the device is determined based on this information. The problem is that a special location device is needed in the location operation, which consumes also much power. Besides the initial outlay of the device is significant, at least concerning the private user. A further problem in the GPS-system is that there must be a direct visual contact for the location device to at least three satellites, when the location cannot be made in internal spaces.

A location system has been realized to substitute the GPS-system to function also in the mobile station network. In that case the location takes place in a separate component placed in the mobile station network. Such solutions are described for instance in the publications WO 9205672 and GB 2280327. In one embodiment the location is effected so, that the cellular phone selects three strongest base stations, takes in turn a contact to them and determines the distance between the cellular phone and the base stations. Thereafter the mobile station sends e.g. distance information (d_1, d_2, d_3) and the base station's and its own identities to the location unit in the network, which unit determines the location by a circle method or a hyperbolic method. These methods are well-known coordinate calculation methods. Thus the location is at the disposal of the network and it can be sent back to the cellular phone. The location unit can also exist in the cellular phone, but in this case location information concerning all the base stations in the network must be recorded to the location unit in the cellular phone. This is not, however, practical, because the

operator is not willing to give this information to the public, and because the network is alive all the time, the information is not either updated.

One of the disadvantages of the before-known solutions is that the location information is not directly at the disposal of cellular phones, but the network must send it to the cellular phone using for instance a short message. One drawback is also that the one location calculation request causes a dispatching need of many short messages, which is not very sensible, if many devices desire continuous location information in the same region.

The object of the present invention is to solve the above-mentioned problems. The object of the present invention is particularly to set forth a location method that can be realized also in the mobile station network and that does not load the mobile station network capacity excessively. A further object of the present invention is to present a user-friendly location device that can easily be combined to the existing mobile station.

For the characterizing part of the present invention reference is made to the claims.

In the method according to the invention to determine a location in a predetermined coordinate system, as a chart coordinate system, information signals are sent by the transmitter concerning the transmitter data and these information signals are received by a terminal device. In compliance with the invention to these information signals are combined location data of the transmitter, such as accurate coordinate information in the coordination system. Further on in the terminal it is determined the distance of the terminal device for instance based on the signal received from the transmitter. Coordinates of the terminal device are calculated based on the received location information of the transmitter and the distance of the terminal device from the transmitter. The terminal device preferably receives information signals from at least three or more transmitters. In one advantageous embodiment of the invention mobile station network can be utilized in the location operation, whereat the transmitter serves as a base station and the terminal device as a mobile station, to which have been combined the qualities needed in the location operation.

An advantage of the present invention compared with the prior art is that the location determination does not require dispatching of numerous messages from the mobile

station network (e.g. short messages from the GSM-system). Also the information needed for the location determination is at the disposal of all mobile stations simultaneously, or if desired the acquirement of the location information can be limited to only the persons, who have the encryption key. One advantage of the invention is also that the location can be determined continuously; the location determination in the network according to the prior art functions only if requested and there is always delay in the transmission of the location information.

In one preferable embodiment of the present invention the location codes connected to the information signals are encrypted using a predetermined encryption method. A preferable encryption method can be altered after certain intervals in order to improve the encryption. The advantage of the encryption is that if desired the mobile station operator may limit the use of the location method and sell the right of use to persons wanting it.

When the mobile station network is used, situations may occur, in which the distance of the terminal device from the base station is below a certain threshold value that can consist of e.g. the desired location accuracy or generally the greatest location accuracy, for example about 500 m, so the location of the transmitter is determined as that of the terminal device. Then the location takes place very quickly, because no calculation is needed. On the other hand the mobile station can be in the region, where the distance of the base stations from each other is below the predetermined threshold value, for instance in densely populated area in so-called picocell environment. Also here the location of the mobile station is determined the location, that the transmitter, to which the terminal device is in contact, has informed.

The mobile station system is preferably based on the digital technique, as the GSM-technique, DCS1800-technique or similar. Advantageously a general transmission channel or other channel suitable for this purpose is used for the signal dispatching.

The location system in a predetermined coordination system according to the invention includes a transmitter, by which information signals about the transmitter data will be sent, and a terminal device, by which information signals will be received. According to the invention the system includes also an adding device that is arranged to connect the transmitter's location data to the information signals in the coordination system. Further on according to the invention the terminal device includes means for

the determination of the distance between the terminal device and the transmitter and to determine the location of the terminal device based on the received location information and the distance of the terminal device from the transmitter. The adding device may as such belong to the mobile station network or it can comprise a component outside the network being connected to the mobile station network. The terminal device can also include a subscriber's identification unit, as a SIM-card (SIM, Subscriber Identity Module), to which have been combined the qualities needed for the determination of the distance and the place.

In one embodiment the system is based on the mobile station network, whereby the transmitter serves as the base station of the mobile station network and the terminal device serves as the mobile station. The system preferably includes at least two transmitters. The system can also include encryption means in order to encrypt the location information combined to the information signals using a predetermined encryption method. The encryption means may belong for instance to the adding device or they can also be located to any other suitable network element in the mobile station network or outside it.

In one solution according to the invention each base station sends individual information needed for the location data, as the coordinates of the base station in question and of the adjoining cells as wells as time and distance information, in the signalling and transmission channel of the mobile service system. In the present GSM-system cam be used each base station's own CBCH-channel (CBCH, Cell Broadcast Channel), which all the mobile stations connected to the base station can listen. In the future Phase 2+ GSM it is possible to use a packet data network, for example Packet Radio GPRS. The location information sent in the signalling or transmission channel can be encrypted by some encryption algorithm, the encryption key of this algorithm can also be sold e.g. for a certain time period or the encryption key can also be sold by license directly to the equipment manufacturer. After receiving the encryption key, the mobile station may discharge the received coorc ie data. Because of mathematical requirements the mobile station needs .. least three base stations to calculate the location information for instance by the circle method or the hyperbolic method.

The invention will be described in the following by the accompanying exemplary embodiment with reference to the enclosed drawing, in which:

Figure 1 shows a system according to the invention; and
Figure 2 shows the use of the circle method in one embodiment of the invention.

The mobile station system, based in this example on the GSM-technique, includes three base stations 1^1, 1^2 and 1^3. Each base station sends for instance in the CBCH-channel its own location information and also that of the surrounding base stations. It is preferable to limit the amount of surrounding base stations for example by a certain distance value. To each base station have also been connected an adding device 3 and encryption means 5 (in this example connection is made in an exemplary way only to the base station 1^2), by which it is possible to add location information to the information signal and encrypt them by certain suitable encryption algorithm. Adding and encryption means can be controlled centrally for instance from the mobile station exchange or outside the network. Fig. 1 shows also the mobile station 2 being an integral part of the mobile station system. There can be almost an unlimited number of mobile stations in the system. To the mobile station have also be connected determination means 4, by which the distance to each base station is defined and the location of the mobile station is calculated on the grounds of the distance and location information received from base stations 1^1, 1^2 and 1^3. To the mobile station 2 has additionally been connected the subscriber's identification unit, SIM-card 6. Also to the SIM-card can be connected the determination means 4.

In the example according to Fig. 1 the system includes an adding and encryption device 3, 5, belonging to the GSM-network. The device 3, 5 has means, by which it can communicate with the GSM- terminal devices through base stations 1. The device 3, 5 comprises in the GSM-network the Cell Broadcast Entity (CBE) communicating with the Cell Broadcast Center (CBC), which in turn transmits messages to the base station controller BSC (BSC, Base Station Controller), which then furthers the messages to the base station. The device 3, 5 can also be directly connected to the base station controller, whereby it is in the position corresponding CBC. The location information of the base stations is found advantageously for the adding device 3 from the operator's cellular design system or the network management system OMC (OMC, Operating and Maintenance Center).

In the following it is presented referring to Fig. 1 one example of the function of the location system in the mobile station network. The mobile station 2 takes for instance

in the intensity order contact to base stations 1^1, 1^2 and 1^3, gets coordinates from them and preferably also the distance information. (Distance information in the GSM-system could be e.g. Timing Advance (TA) in the BCCH-channel). Having received this information from at least three base stations, the mobile station can in the grounds of this information calculate its own location.

On the other hand the mobile station 2 may get the coordinates of the mobile stations also by one contact, if all the base stations 1^1, 1^2 and 1^3 send in addition to their own location information also that of the surrounding base stations. This kind of a procedure makes the location determination remarkably swifter. For the determination of the distance information is then used the field intensity or other suitable information available from the base station without making contact to it. However, if the terminal device would find out by the first contact also the location information of the adjoining cells, the contact-making to other base stations could be significantly quicker, because for instance there would not be any need to wait for the coordination information sent in the Cell Broadcast -channel between certain time periods (1/30 s), during each contact.

In the following it is presented with reference to Fig. 2, one calculation method according to the invention to calculate the location coordinates of the mobile station. The location codes (x_o, y_o) can be defined for instance by the already before known circle method from the equation (1), when the coordinates $P_1 = (a_1, b_1)$, $P_2 = (a_2, b_2)$, $P_3 = (a_3, b_3)$ and the distances d_1, d_2, d_3 are known from Fig. 2. The location coordinates P_1, P_2 and P_3 are received from each base stations by forming a connection to them. Correspondingly the distances d_1, d_2 and d_3 are determined in the mobile station from the strength of the received signal.

$$\begin{aligned} (x_o - a_1)^2 + (y_o - b_1)^2 &= d_1^2 \\ (x_o - a_2)^2 + (y_o - b_2)^2 &= d_2^2 \\ (x_o - a_3)^2 + (y_o - b_3)^2 &= d_3^2 \end{aligned} \qquad (1)$$

Correspondingly in the GPS the distances are found by calculating the running time delay from the satellite to the receiver from the accurate time based on the atom clock. It is not appropriate in the mobile station system to transmit absolute time to the mobile station, but instead the location can be calculated by relative time

differences. In this case four base stations are needed instead of three base stations to get the location in a two-dimensional space.

The accuracy of the location determination is limited by the accuracy of the distance measurement. For instance in the GSM-system the measuring accuracy of TA (Timing Advance) is ±555 m, shown in Fig. 2 by the marking Δd_2. The coordinate information can instead be very accurate, if needed. The accuracy of the location determination increases, when there is more than three base stations in the use. For the distance calculation can be used also a "real" running time delay before the information is quantified to some value of TA. It is also possible to use the OTD-value (Observed Time Difference) needed in the synchronized channel exchange, but also then four base stations are needed, but a bit more accurate location determination may be obtained. It would also be possible to use as the GSM-system the dispatch of the coordinates of the base stations and an accurate time information to the terminal device.

In city environment, where micro-, pico- or even nanocells are used, the cell radius can be only a few dozen meters. In this case the distance information or similar between the mobile station 2 and the base station 1 is not necessarily needed at all, because only the coordination information of the base station would be sufficient for most embodiments. For example a location algorithm could upon the location determination observe, that it is located at the moment in a picocell environment, if in its reception area there are n pieces of mobile stations, whose TA is small enough. Then it could determine its location by the coordinates of only one serving base station.

As a summary from the above-mentioned can still be stated as follows. One common practical embodiment of the invention could comprise a location device utilizing the location information, distance information, time data and other identification information of the mobile stations or only some of these obtained from the signalling channel of the cellular phone network. Another embodiment for the location device could comprise a location device integrated to the cellular phone, having a digital map from its location area at its disposal. The user could monitor his location using the map in the display of the cellular phone in real time. The device could also be realized using already existing technics by connecting to the cellular phone a portable computer, whereby the location could be determined by a suitable map programme in

the display of the computer. The telephone could also only show its own location coordinates in the cellular phone display.

The invention is not be restricted only to the embodiments explained above, but many modifications are possible within the inventive concept defined by the claims.

CLAIMS

1. A method for determining a location in a predetermined coordinate system, in which method information signals are transmitted by a transmitter concerning the transmitter data and these information signals are received by a terminal device, c h a r a c t e r i z e d in that to the information signals are combined the location information of the transmitter in the coordination system and/or the identification data, the distance of the terminal device from the transmitter is defined and the location of the terminal device is calculated based on the received location information of the transmitter and on the distance of the terminal device from the transmitter.

2. A method according to claim 1, c h a r a c t e r i z e d in that a mobile station network is used in the location operation; and that the transmitter is a base station and the terminal device is a mobile station.

3. A method according to claim 1 or 2, c h a r a c t e r i z e d in that at least three transmitters are used.

4. A method according any of the preceding claim 1 - 3, c h a r a c t e r i z e d in that the location codes combined to the information signals are encrypted using a predetermined encryption method.

5. A method according to claim 4, c h a r a c t e r i z e d in that a encryption changing after time periods is used.

6. A method according to any of the claims 1 - 5, c h a r a c t e r i z e d in that when the distance of the terminal device from the transmitter is below a predetermined threshold value, the location of the terminal device is defined as that of the transmitter.

7. A method according to any of the preceding claim 1 - 6, c h a r a c t e r i z e d in that when the terminal device observes that it is located in the region, where the distance of the transmitters from each other is below a predetermined threshold value, the location of the terminal device is defined as the location informed by the transmitter, to which the terminal device is in contact.

8. A method according to any of the preceding claims 1 - 7, characterized in that the mobile station system is based on the digital technique, as GSM-technique; and that information signals are transmitted in a common transmission channel.

9. A method according to any of the preceding claims 1 - 8, characterized in that to the information signal sent by the transmitter are combined the location information and the identifying information of the surrounding transmitters.

10. A method according to any of a the preceding claim 1 - 9, characterized in that the location operation is effected in an identification unit of the subscriber combined to the mobile station, as in a SIM-card.

11. A system for determining a location in a predetermined coordinate system, which system includes a transmitter (1), by which information signals are transmitted concerning the transmitter data and a terminal device, by which these information signals are received, characterized in that the system includes an adding device (3) arranged to combine to the information signals the location information of the transmitter in a coordinate system; and that the terminal device (2) has means (4) for determining the distance between the terminal device and the transmitter and the location of the terminal device based on the received location information of the transmitter and the distance of the terminal device from the transmitter.

12. A system according to claim 11, characterized in that the system is based on the mobile station network; and that the transmitter (1) is the base station of the mobile station network and the terminal device (2) is the mobile station.

13. A method according to claim 11 or 12, characterized in that the system includes at least three transmitters (1^1, ..., 1^n).

14. A method according to any of the preceding claims 11 - 13, characterized in that the system includes encryption means (5) for encrypting the information combined to information signals using a predetermined encryption method.

15. A method according to claim 14, characterized in that the encryption method of the encryption means has been arranged as changing during time periods.

16. A system according to any of the preceding claim 11 - 15, characerized in that the mobile station system is based on the digital technique, as GSM-technique; and that information signals are transmitted in the common transmission channel.

17. A method according to any of the preceding claim 11 - 15, characterized in that the transmitter (1) is arranged to combine to the information signal the location and identifying information of the transmitters (1^1 , ... , 1^n) surrounding the transmitter.

18. A method according to any of the preceding claim 11 - 17, characterized in that the system includes a subscriber's identification unit (6) combined to the mobile station (2) and having means (4) for the determination of the distance between the base station (1) and the mobile station as well as the location of the mobile station.

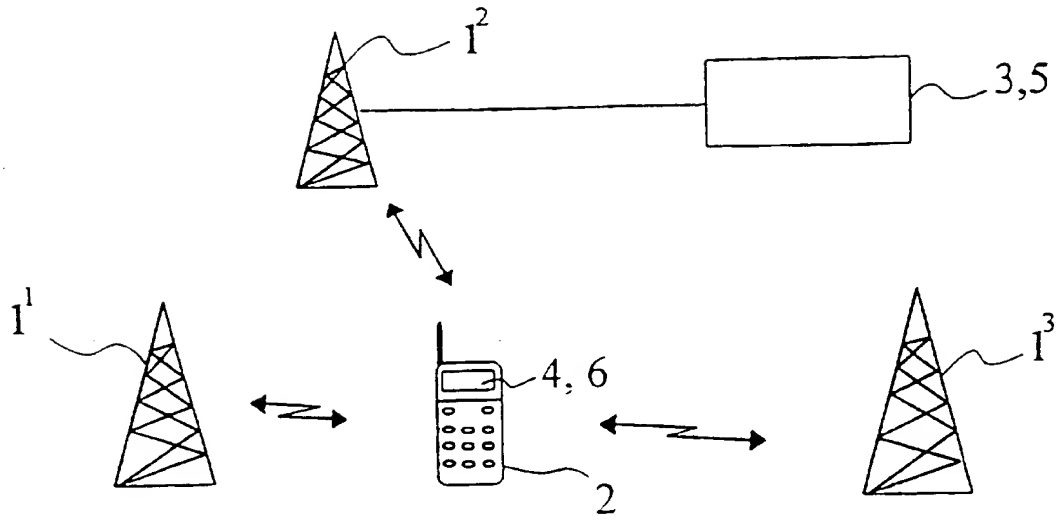

Fig 1

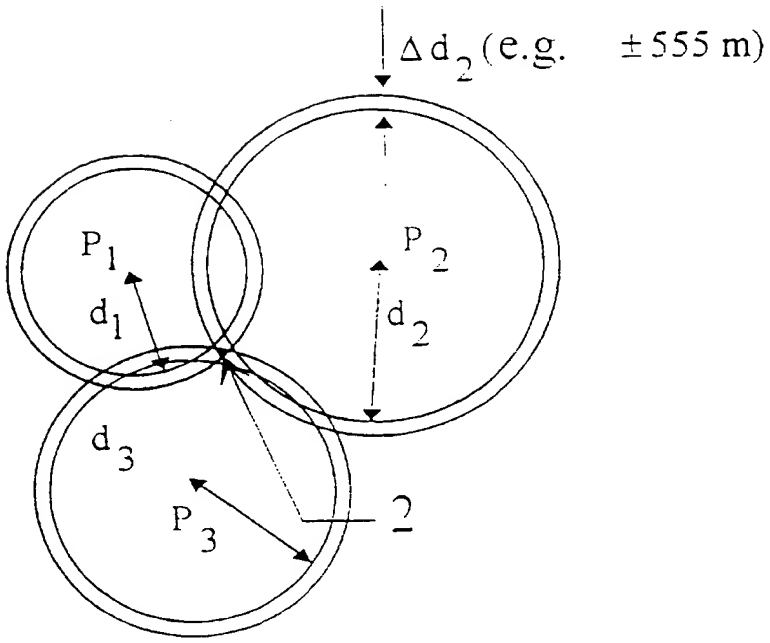

Fig 2

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 7/38, G01S 5/14
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04Q, G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

JAPIO, WPIL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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International application No.
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